#4/Priority Paper 4.3.01
C. Wills

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1. Your reference 474 GB

2. Patent application number
(The Patent Office will fill ...) 0013141.7

31 MAY 2000

3. Full name ... of or each applicant *(underline all surnames)*

Renishaw plc
New Mills
Wotton-under-edge
Glos GL12 8JR

Patents ADP number *(if you know it)* ADP 2691002

If the applicant is a corporate body, give the country/state of its incorporation: incorporated in UK

4. Title of the invention

A tracte for a measurement scale and apparatus for traisuring the scale

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Ross Cavill
Patent Dept
Renishaw plc
(address above)

Patents ADP number *(if you know it)* 7968650001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

Yes

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9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	10
Claim(s)	0
Abstract	0
Drawing(s)	7

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature [signature] Date 31-5-00

12. Name and daytime telephone number of person to contact in the United Kingdom A. ILES 01453 524 524

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A track for a measurement scale and apparatus for tensioning the scale

The present invention relates to a track arrangement for carrying a measurement scale for use in scale reading apparatus, and to apparatus and a method for tensioning a measurement scale.

A known form of opto-electronic scale reading apparatus for measuring relative displacement of two members comprises a length of scale on one of the members, having scale marks defining a periodic pattern, a read head provided on the other member, means for illuminating the length of scale, periodic diffraction means for interacting with light from the scale marks to produce interference fringes having movement relative to the read head and detecting means in the read head responsive to the fringes to produce a measure of the displacement.

An example of such apparatus is disclosed in EP-A-0 207 121 and also US-A-4,974,962. Typically, the length of scale could be of spring steel with a surface layer of copper. US-A-4,926,566 discloses a method of producing a length of scale, in the form of a flexible tape produced by rolling, the pitch of the scale marks being 20 μm or 40 μm for example.

Conventionally the length of scale may be carried by being received by a track, for example comprising an aluminium extrusion, the lower part of the track being attached to a surface, for example by screws or bolts, and the upper part of the track being formed to receive the length of scale - see Fig. 1 which is a section through a length of track 1 which is attached to a surface 2 by screws 3 spaced apart along its length and lengths of

clamping strip 4, the upper part of the track 1 receiving a length of scale 5 which has been slid into it.

The upper part of the track 1 has scale holding elements 1a for keeping the scale in place.

However, such an arrangement can be difficult to make and to install. The small ride-height tolerance of a typical read head means that the track 1 requires accurate manufacture. The necessary clearance for the sliding fit of the scale 5 in the track 1 demands that the scale be manufactured even more accurately to compensate for this clearance.

It is not desirable to clamp the scale 5 securely to the track 1 because there may be relative thermally induced movement between the scale and track, particularly if dissimilar metals are used. For this reason the prior art track shown in figure 1 allows sliding movement of the scale. The scale will produce more accurate readings if it is held at a fixed position, both lengthwise and laterally but should not be clamped to the track, and should not be subjected to any deviations in the forces holding it in position.

According to one aspect of the present invention there is provided an elongate track comprising a channel, the channel being adapted for holding a measurement scale therein, characterised in that the track is adapted for attracting magnetically the scale into the channel of the track.

The track could hold a length of magnetic material (for example a length of flexible magnetic material such as ferrite rubber) for holding the scale

magnetically. In this case, the length of magnetic material could be in the channel of the track, the scale being above the length of magnetic material, for example sitting on edge portions (which are, for example, below the upper surface of the track) along respective sides of the channel.

The track could be attached to the surface by screws passed through holes in it. Such holes could be at the bottom of the channel or in the track alongside such a channel.

The track could be an extrusion, for example an aluminium extrusion.

Alternatively the track could be a length of magnetic material for example ferrite rubber, having the channel formed integrally therein.

It has been found that the scale may lift from a track or similar support under conditions where it is under compression. At least in order to avoid lifting the present invention according to a second independent aspect employs a scale tensioner.

One scale tensioning device is described in US 4559707 (Heidenhain). However this and other scale tensioners are directed to correcting errors in the scale's pitch rather than to prevent lifting.

The constructional details of these prior art tensioners differ from the proposed invention which provides a measurement scale tensioning device comprising a preloadable resilient member operable to urge the scale into tension.

The device may include a resilient member loading part operable to preload the member and operable to release the load.

The invention according to yet another aspect provides a method of tensioning a measurement scale, comprising the following steps:

providing a measuring scale, and scale tensioner;
preloading the scale tensioner;
mounting the scale to a substrate;
securing one end of the scale to the substrate and clamping the tensioner to the substrate adjacent the other end of the scale;
releasing the preload in the tensioner to cause a tension in the scale;
securing the said other end of the scale to the substrate whilst maintaining the tension in the scale, and;
removing the tensioner from the substrate.

Preferably the method includes the step of providing a track to house the scale.

Preferably the tensioner is mounted on the track prior to being secures to the substrate. More preferably the said tensioner securement is provided by fixings passing through a hole or holes in the track.

The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Fig. 1 is a section through a known arrangement for carrying a length of scale by a length of track;

Fig. 2 is a plan view of a length of track forming a first embodiment of the invention according to the first aspect of the invention;

Fig. 3 is an enlarged view of part of the length of track of Fig. 2;

Fig. 4 is a section through the length of track and showing a screw through a hole in it;

Fig. 5 is a section through the length of track and showing a length of scale held on it;

Fig. 6 is a section through a wider form of track;

Fig. 7 shows a use of the wider form of track;

Fig. 8 is a plan view of a length of track forming a further embodiment of the invention;

Fig. 9 is an enlarged view of part of the track of Fig. 8;

Fig. 10a) is a section through A-A of Fig. 9, Fig. 10b being an enlarged view of part of Fig. 10a);

Fig. 11 shows means for fixing lengths of track end to end;

Fig 12 is a sectional view of another type of track forming another embodiment of the invention;

Fig 13 is a sectional view of yet another type of track forming yet another embodiment of the invention;

Figs 14&15 show a plan and side view respectively of a scale tensioning device according to the second aspect of the invention, and;

Fig 16 is an enlarged partial view in the direction of arrow "X" in fig 14.

Referring to Figs. 2-5, a length of aluminium extrusion provides a length of track 6 attachable to a surface by screws 7 passed through holes 8 spaced apart (for example with a pitch of 10cm) along the length of track 6. The length of track 6 is formed with a channel 9 running centrally

along its length, the holes 8 being at the bottom of the channel 9. Also, along each side of the channel 9 is an edge portion 10 below the upper surface of the length of track 6.

With lengths of track 6 attached to a surface by screws 7, between each pair of holes 8 there is laid a strip 11 of flexible magnetic material, held on to the bottom of the channel 9 by a strip 12 of double-sided adhesive tape. By way of example, the strips 11 could be strips of ferrite rubber such as that provided by Magnet Applications Limited, of Northbridge Road, Berkhamsted, Hertfordshire HP4 1EH, England. Then, a length of scale 5 (for example for use in opto-electronic scale reading apparatus) is laid on to the edges 10 and held magnetically in place on the track 6 by the strips 11 of flexible magnetic material.

Fig. 6 shows a section through a wider length of track 6 for use in the arrangement of Fig. 7 in which a read head carried by a sprung read head carriage 13 runs on the length of track 6. A wheel 14 is fixed via a bracket to the read head carriage 13 and the assembly sprung towards the scale 5. The wheel runs on the length of track 6, maintaining the correct scale to read head gap substantially irrespective of undulations and steps in the surface to which the length of track 6 is attached.

In the above embodiments, the length of track 6 is formed with a channel 9 running centrally. Referring to Figs. 8, 9, 10a) and 10b) an alternative form of length of track 6a comprises an aluminium extrusion formed with holes 8a spaced apart along its length for attaching the track 6a to a surface by screws, the holes being offset from the longitudinal centre line of the length of track 6a. Also offset from the centre line is a channel 9a

along each side of which there is an edge 10a. In use, the length of track 6a is attached to a surfac , a strip of flexible magnetic material is held on to the bottom of channel 9a by a strip of double-sided adhesive tape and a length of scale is laid on to the edges 10a and held magnetically in place by the strip of flexible magnetic material. Such a structure may be used, like with the Fig. 7 embodiment, with a sprung read head carriage to which a wheel is attached, the wheel running on the upper surface of the length of track 6 alongside the channel 9a.

Such lengths of track 6 or 6a may be placed end to end with a small (~0.5mm) clearance. This is satisfactory unless the surface to which they are attached is uneven. A solution is to make each end of such a length of track as shown in Fig. 11 so two ends plug together by virtue of dowels 15 and holes 16. In practice this could be achieved with two keyhole slots open at the bottom, a suitable dowel-pin being fixed in one of the holes. This enhancement would be particularly useful when used in conjunction with a sprung read head carriage.

The scale may take the from shown in fig 12. In this embodiment an aluminium extrusion 20 having the profile is used as a scale supporting track. The extrusion 20 has a channel 22 for accommodating heads of securement screws etc which pass through holes 24, shown in hidden detail. A further channel 26 is illustrated. Like the other embodiments this channel 26 accommodates a scale 5 and a magnetic strip 11 for holding the scale in place. The strip is held in place by means of adhesive.

It will be noted that there is a slight concavity 28 to the underside of the track. The purpose of the concavity is to ensure that the underside stays in

register with the surface to which it is mounted, and does not form a convexity. A convexity would allow the track to rock on the surface.

In the above embodiments, the magnetic force holding the length of scale in place should not be greater than necessary since it is useful to minimise sliding frictional force between scale and track. This is achieved by the choice of air gap between the scale and the magnetic material.

Fig 13 shows yet another embodiment of the track. In this embodiment a flexible magnetic strip 30 is used to hold the scale 5. The strip is formed from ferrite rubber of the type mentioned above. A channel 32 is formed in the track 30 for holding the scale 5 and provides lateral support for the scale. This track may be held magnetically to a ferrous substrate e.g. a cast iron machine tool bed. In use the track may be temporarily positioned for, say commissioning of the machine and then removed.

A variant of the track shown in fig 13 has a channel slightly wider than the scale to ensure that any radii at the internal corners of the channel do not lift the scale and distort its height.

The tracks shown in figs 12&13 may be employed in a manner similar to manner of use of the other tracks described above.

Referring to figs 14,15&16 there is shown a scale tensioner which may be used to tension any of the scales described above. The tensioner is illustrated with a track similar to that shown in figs 8,9,10a&10b, although a track of any type might be used and in its broadest sense the invention according to the second aspect does not require a track.

There is shown a length of track 6 and a scale 5. The scale is clamped at each end to a substrate e.g. a machine tool bed. Two clamps, one for each end of the scale, each have two parts 42 and 44. The scale is sandwiched and held between these two parts. The two clamps are secured to the substrate. The track 6 illustrated is secured to the substrate also, by means of screws extending through holes 46 in the track 6.

The tensioner comprises a main body 40 having a resilient coil spring 54 housed therein. The spring abuts a plunger 56. The spring 54 is compressible within the body 40 and is held in a compressed state by means of an eccentric pin 52 acting to prevent movement of the plunger 56. The pin 52 is rotatable with shaft 50. The shaft 50 has a slot 62 for manual turning of the shaft with e.g. a screwdriver.

The body 40 is securable adjustably to the support 60 which is in turn securable to the substrate via holes 46 normally used to secure the track to the substrate. Adjustment of the position of the body 40 relative to the support 60 is achieved by means of a slot 48 in the body within the which a clamp screw may pass.

In use the scale and track are mounted to the substrate, and the two end clamps 42 and 44 are attached to the scale. One end clamp is secured to the substrate and the other is loosely attached to the substrate. Support 60 is secured to the substrate via the track mounting holes 46 and the tensioner body 40 is attached to the support and slid toward the loose end clamp. The body is then tightened to the support.

The body is initially in the condition shown in fig 16 i.e. pin 52 holds back the plunger 56 against the force of the spring 54. Slot 62 in the shaft 50 is turned through 180 degrees which moves the pin in an eccentric manner away from the plunger 56. This action releases tension in the spring and forces the plunger against clamp part 42 (at the abutment point 64 shown in fig 16).

The clamp part 42 is attached to the scale 5 so the scale will be forced into tension. The loose clamp can be tightened to the substrate and the body 40 and support 60 can be removed. The now vacant track securement holes can be used to secure the track.

The preload in the spring is adjustable. A screw 66 is used to adjust the tension in the spring to give the correct tension in the scale when the plunger is released.

The period of the marking etc used on a scale under tension may need to be shorter than those an a non tensioned scale because the scale may stretch. A scale with a finer pitch may therefore be provided for use with this tensioner.

It will be appreciated that the present invention may be used with scale other than for opto-electronic scale reading apparatus – for example scale reading apparatus which operates by magnetic or capacitive detection.

Other modifications and variants will be apparent to the skilled addressee.

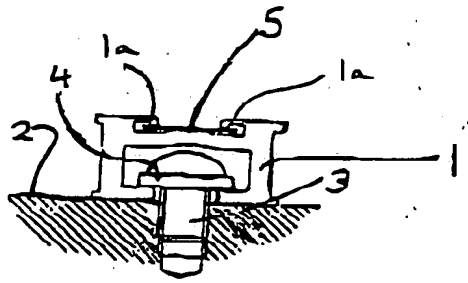

Fig.1

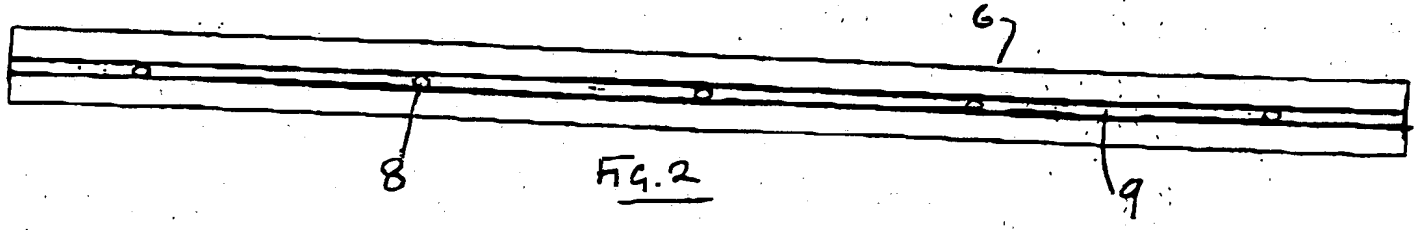

Fig.2

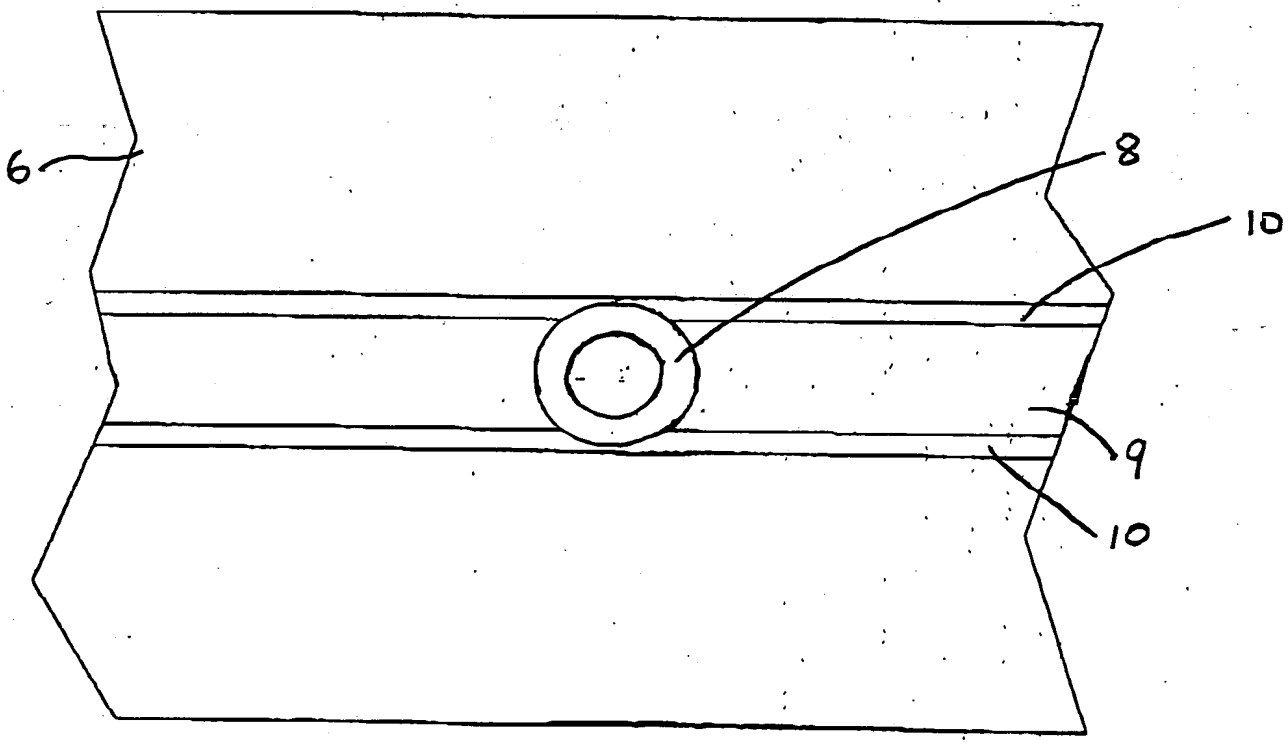

Fig.3

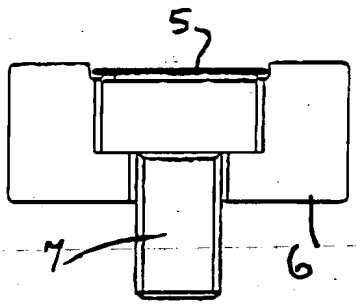

Fig.4

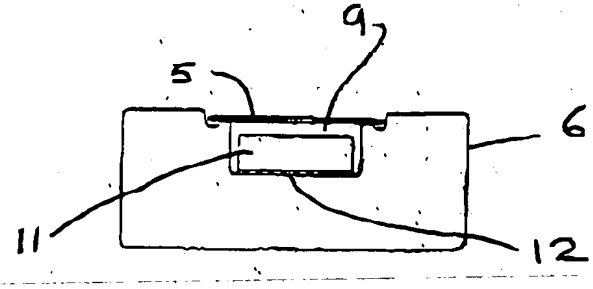

Fig.5

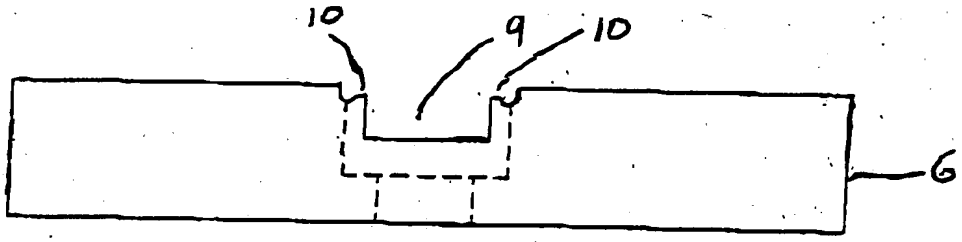

Fig.6

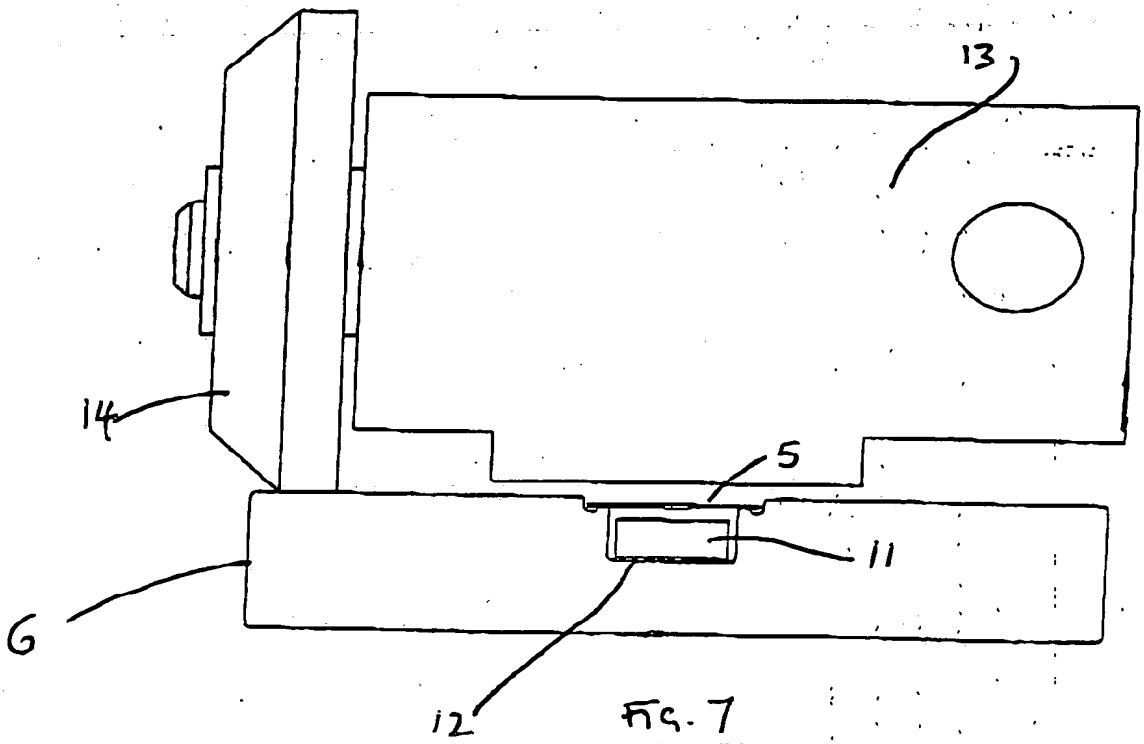

Fig.7

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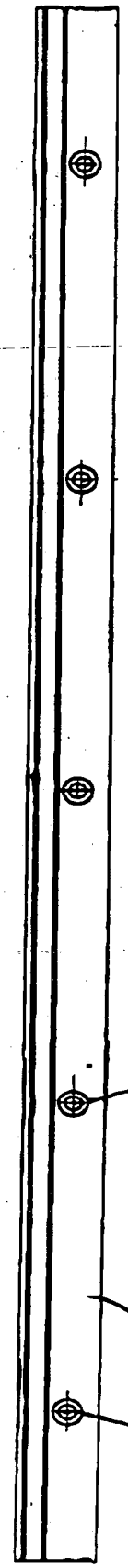

Fig.8

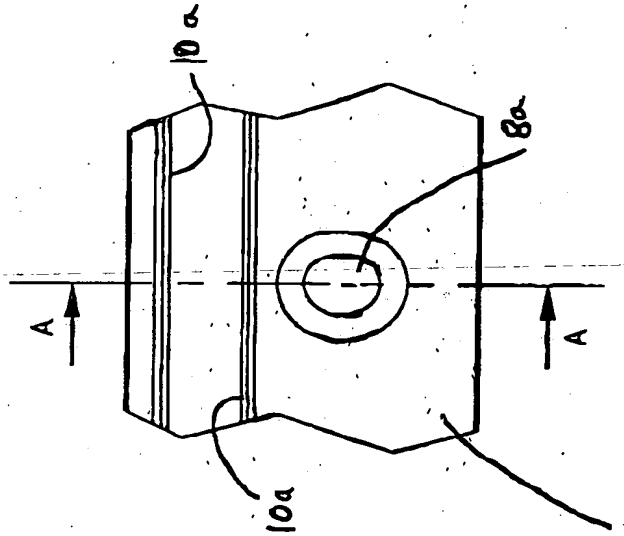

Fig.9

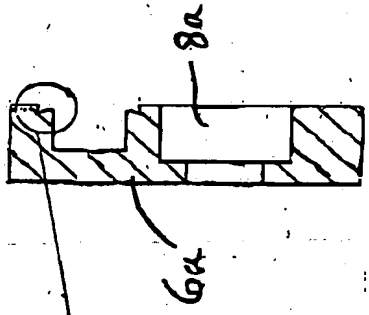

Fig.10a)

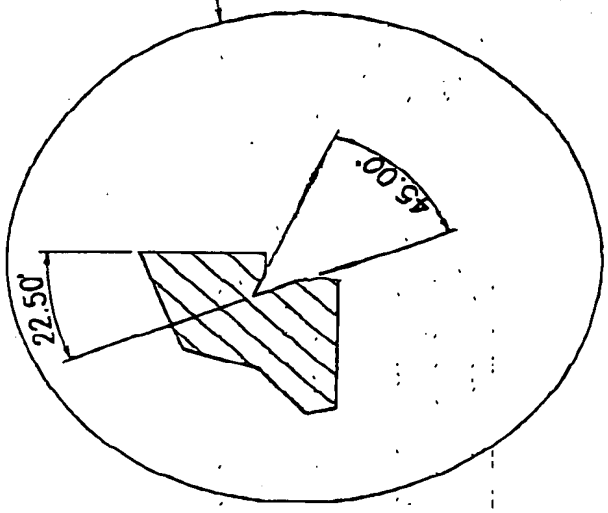

Fig.10b)

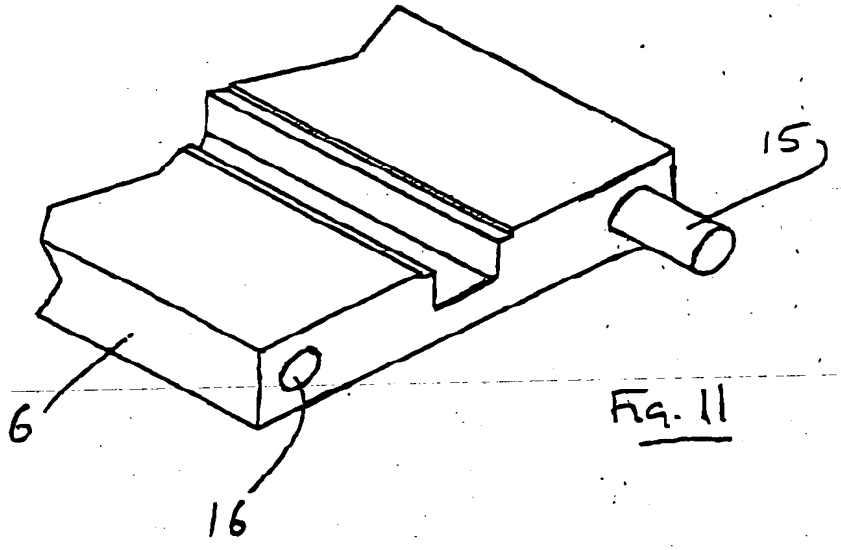

Fig. 11

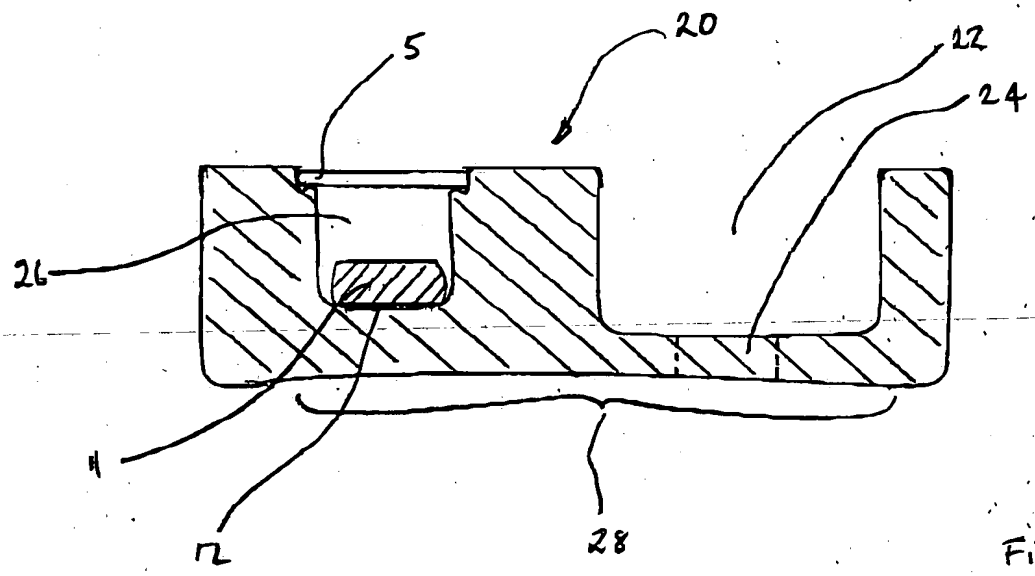

Fig 12

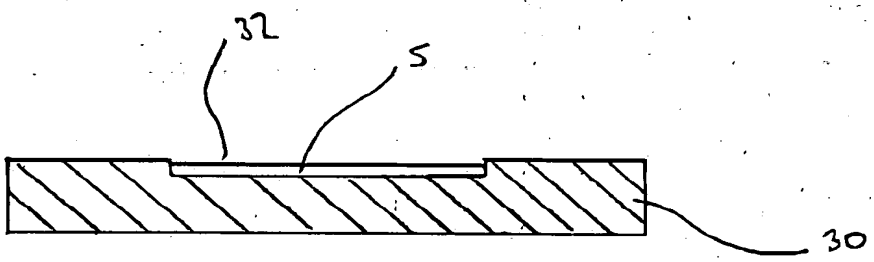

Fig 13

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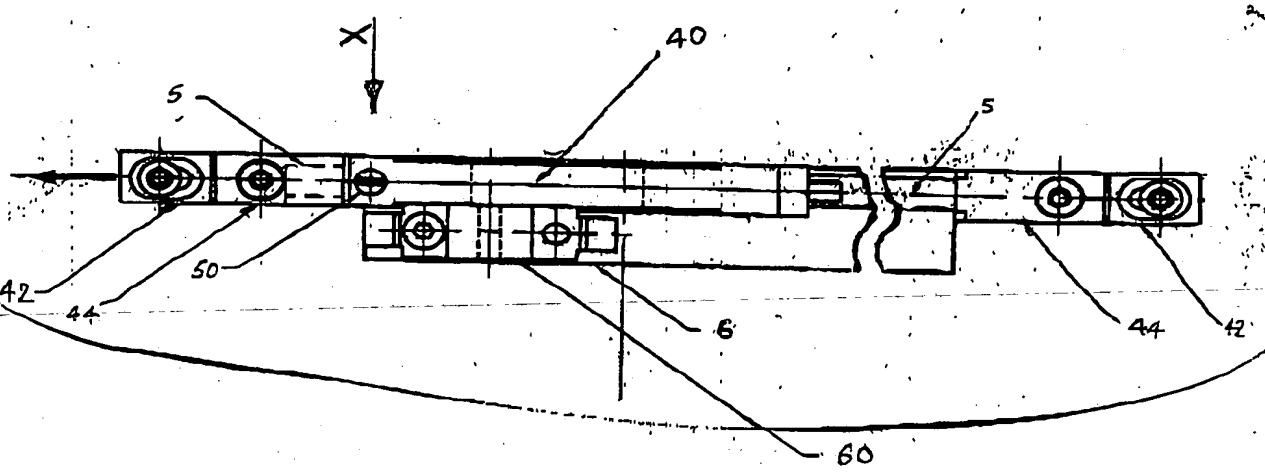

Fig 14

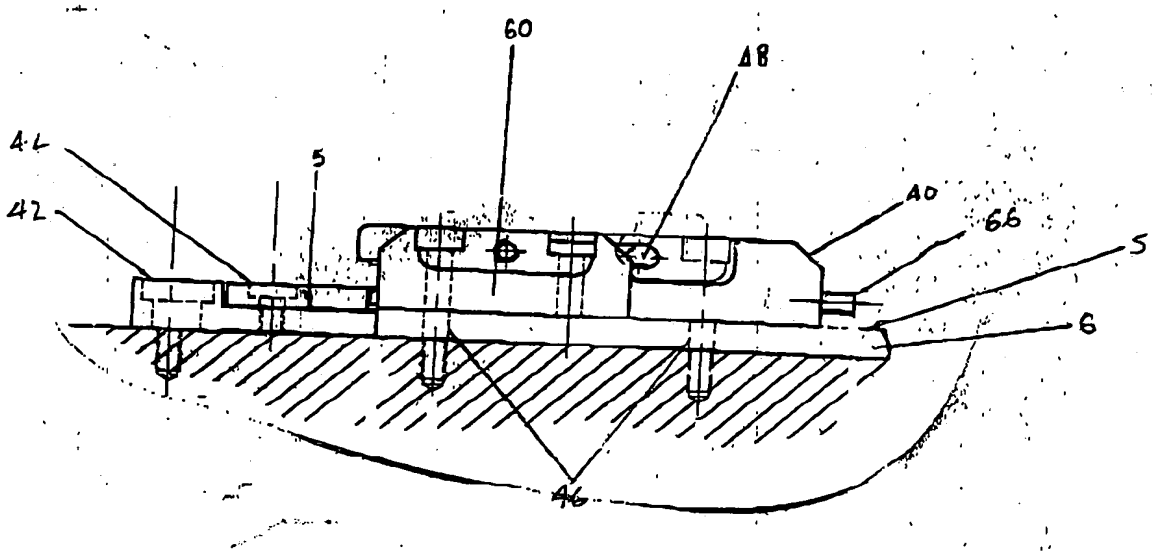

Fig 15

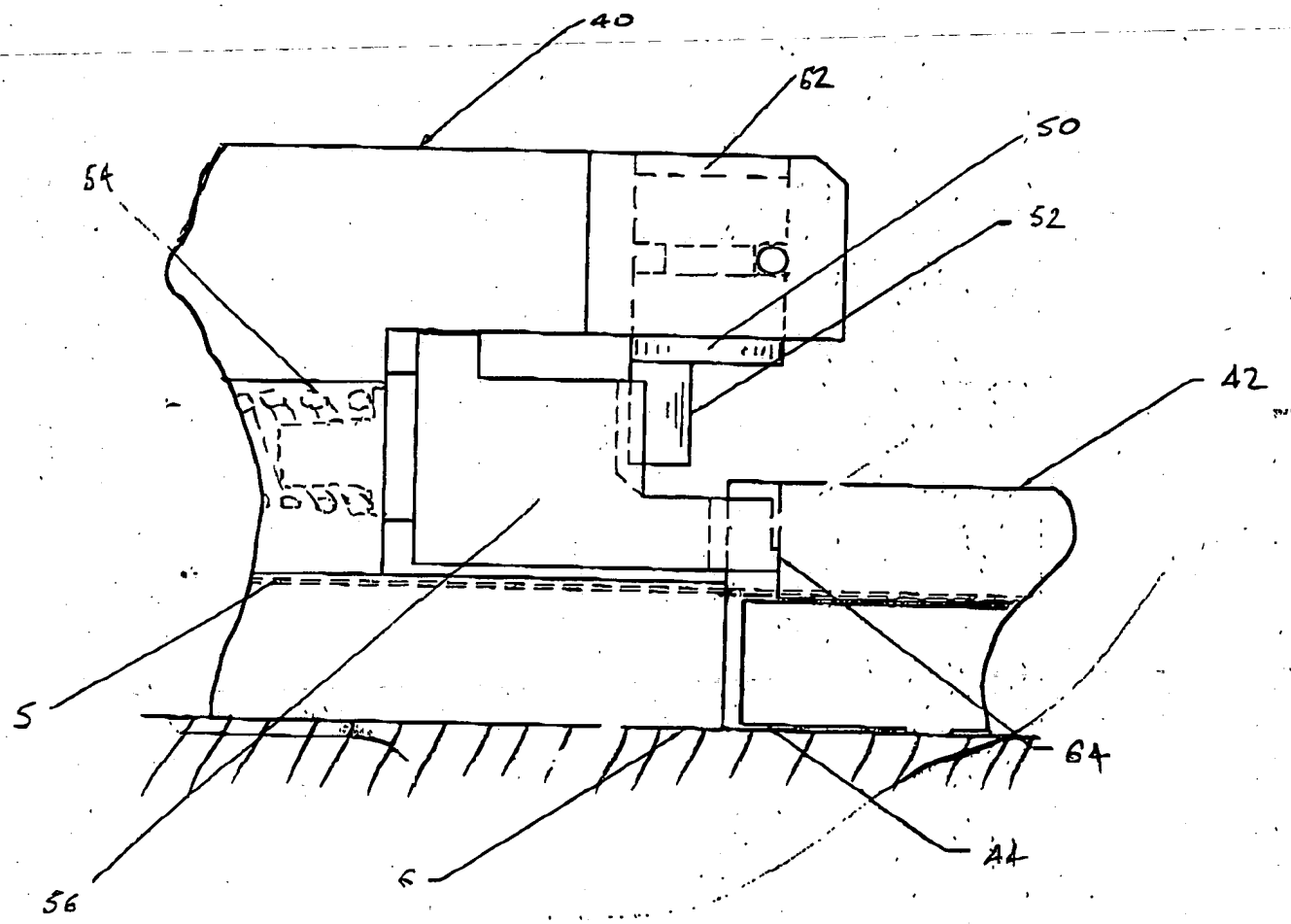

Fig 16